Biophysical Approach in Ecosystem Service Valuation: Spatial Emergy Valuation

Workshop 3. Valuation of Coastal Ecosystem Services and Benefits and Coastal Use Zoning: Tools for Better Planning and Implementation

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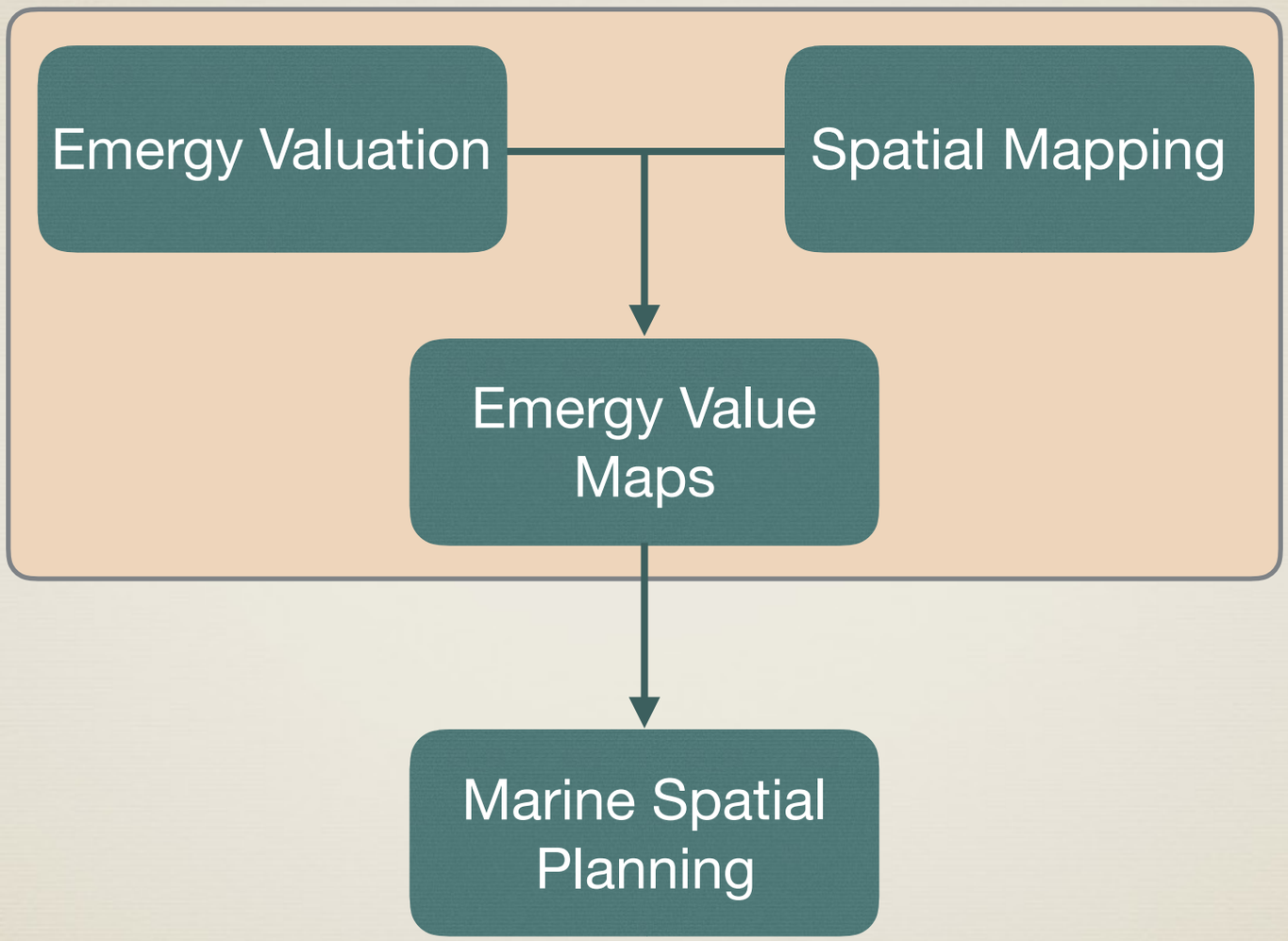
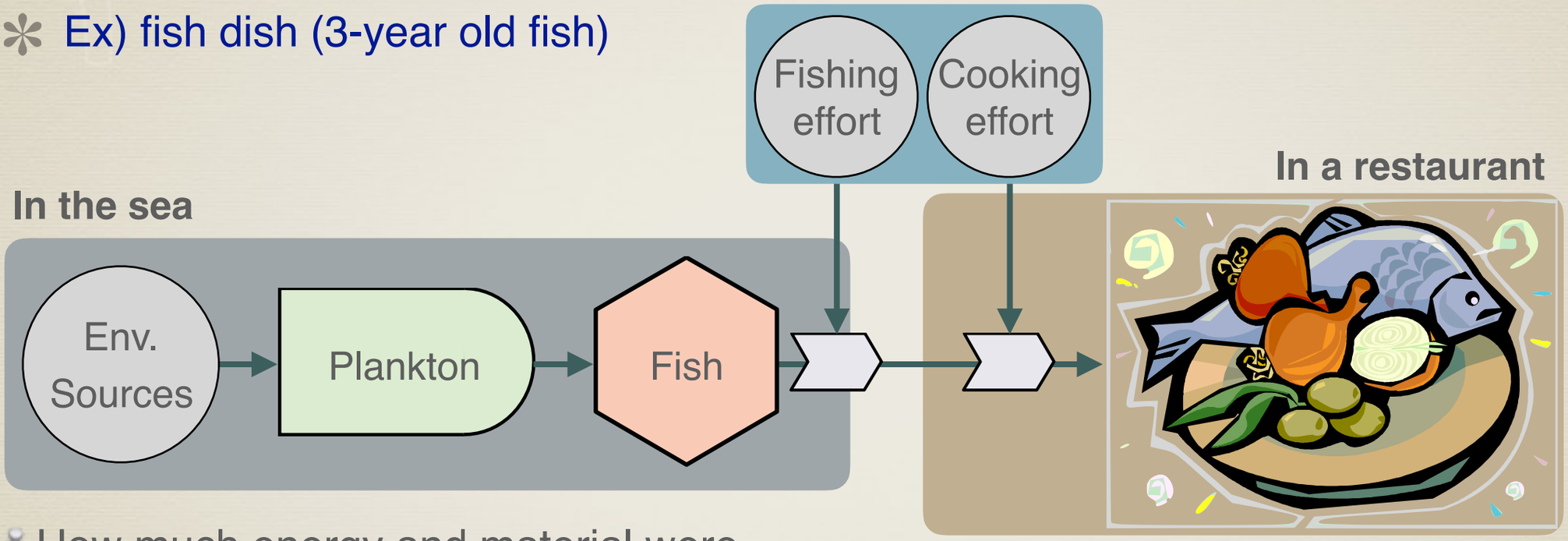
Emergy Methodology

- Emergy valuation and spatial mapping to support marine spatial planning



- How much does a consumer want to pay for the cooked fish?
- How does a cook decide the worth of his/her dish?
- How does a fisherman value his catch?

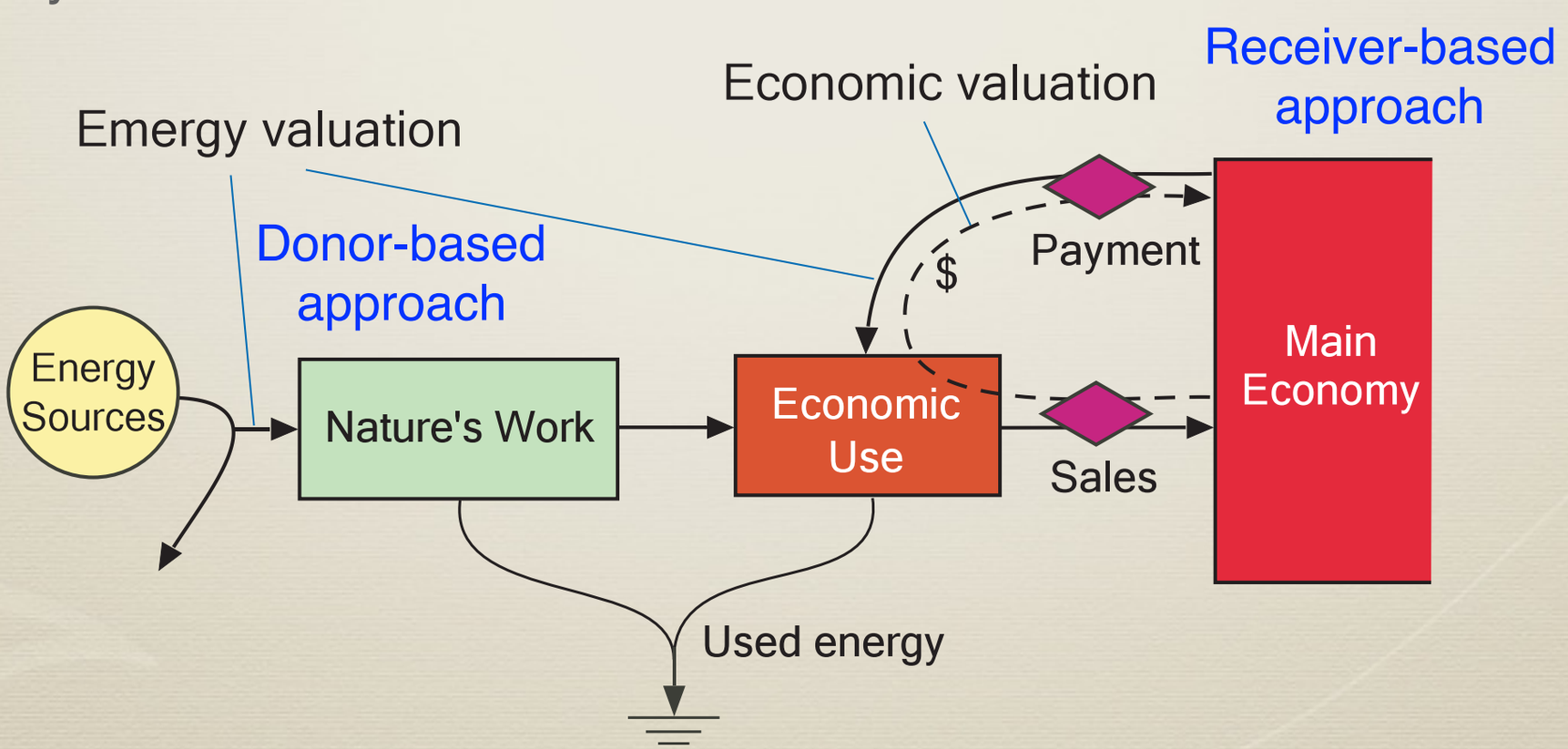
✻ Ex) fish dish (3-year old fish)



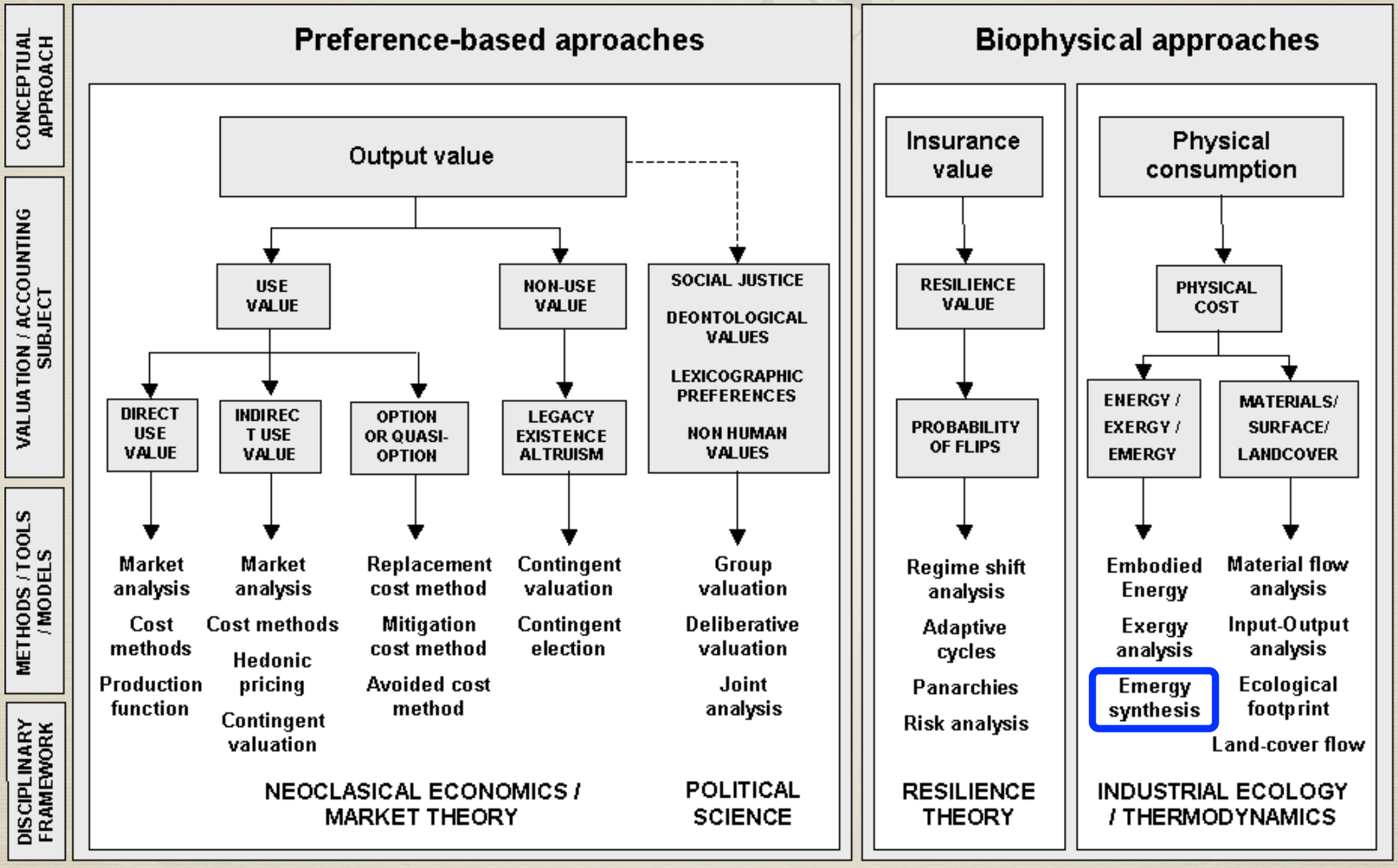
- How much energy and material were required for a fish to grow for 3 years?
  - **Cumulative result** of nature's work for 3 years

- **Cumulative result** of nature's work and efforts of fisherman and cook
- **Calorie content** (cal/fish; J/fish)
  - Most energy lost: 2nd energy law

- Emergy concept
  - **Energy as an alternative common denominator** to value ecosystem services (biophysical value)
  - **Emergy** = Available energy of one kind previously required directly and indirectly to make a product or service (Odum, 1996); **Energy Memory**
    - Solar emergy: Available solar energy used up directly and indirectly to make a service or product (Unit: solar emjoules, sej)
    - include both human efforts and nature's work put into the production of ecosystem services

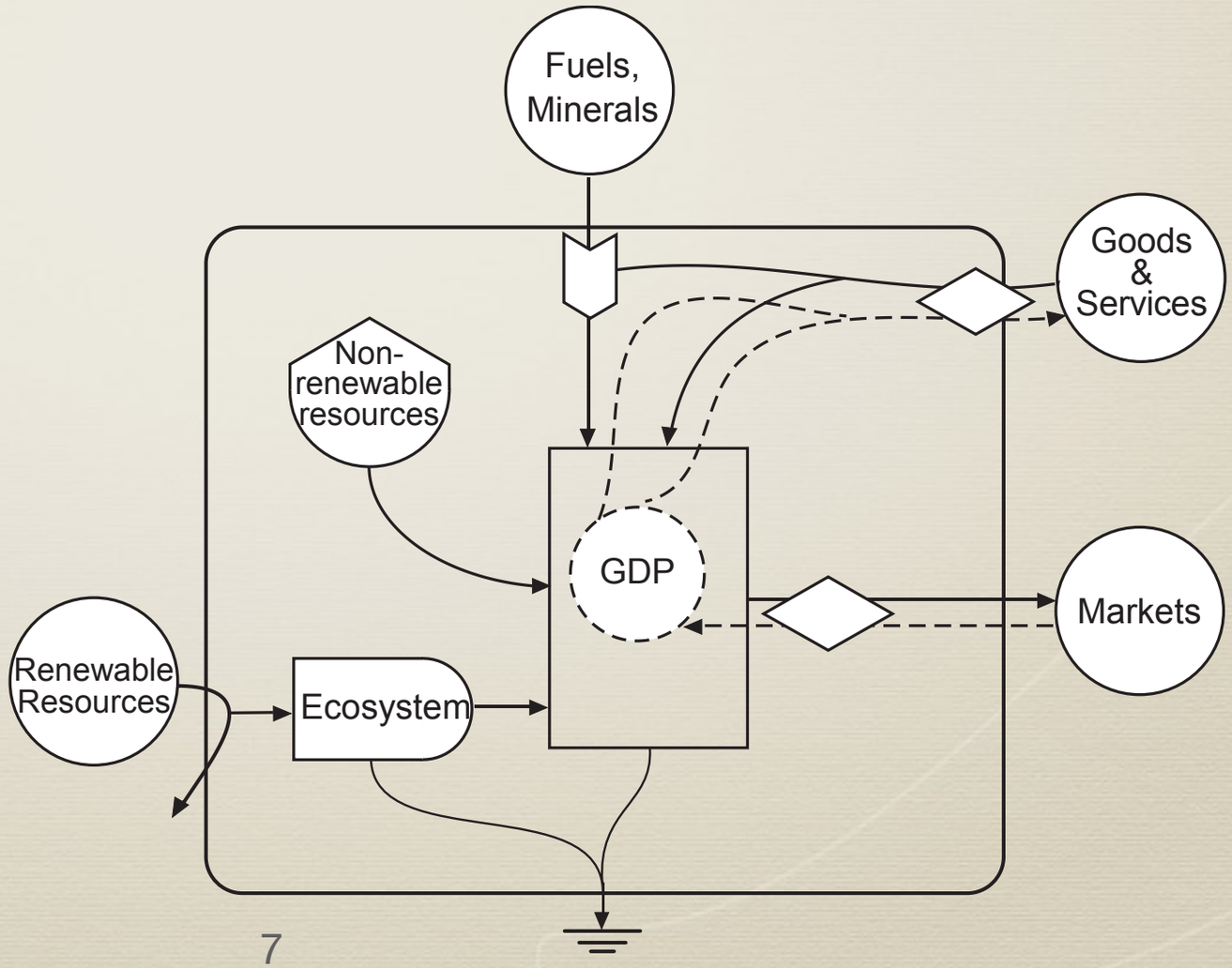


- Emergy methodology as a **biophysical approach** in valuing contributions of ecosystem services to the real wealth of our economy



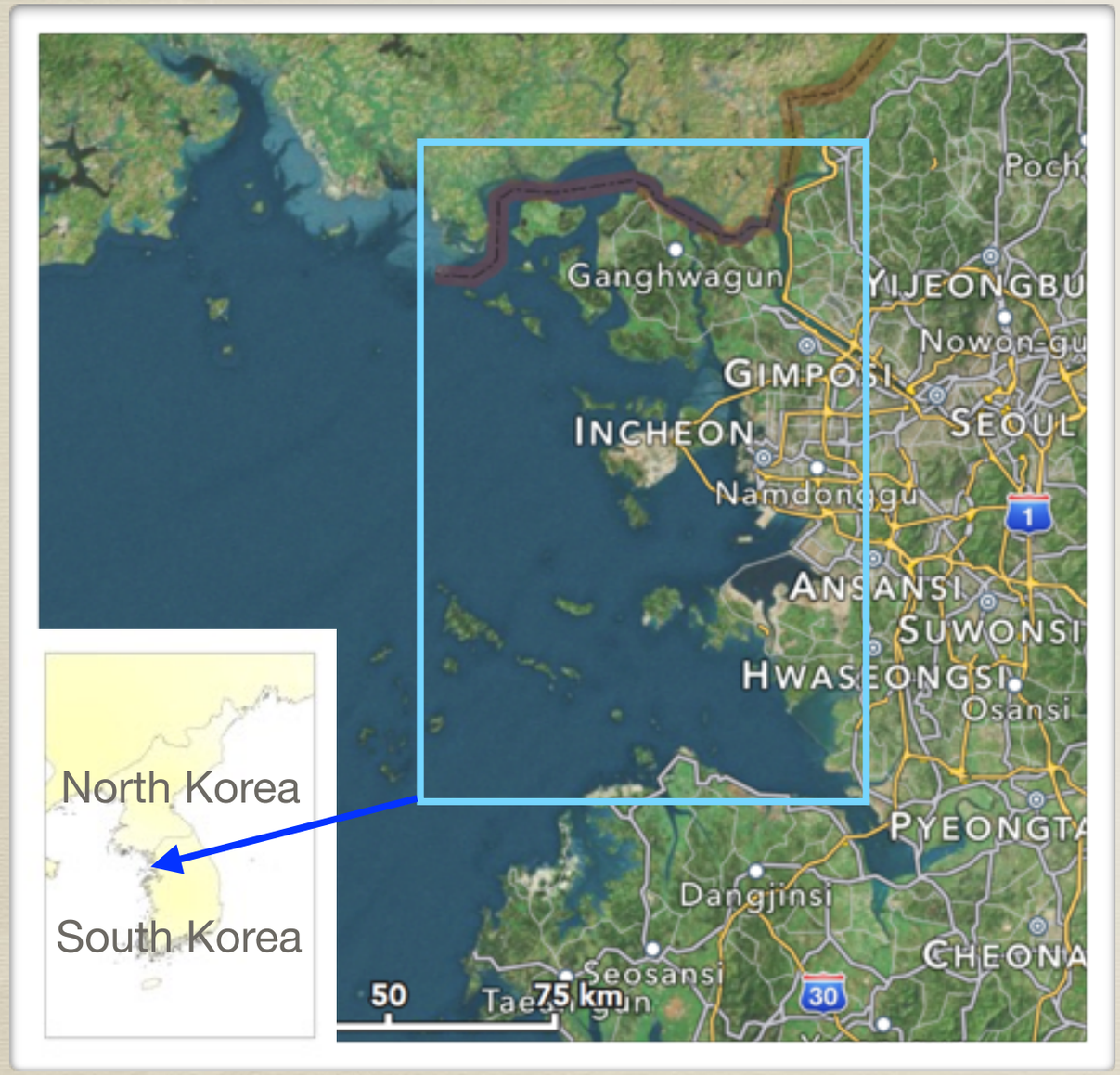
Source : TEEB (2010)

- Emergy and Money
  - Emvalue: em$, em₩, etc
    - Money equivalent of emergy
    - Total value added, supported by total emergy inflow to an economy
  - Emvalue = Emergy flow / Emergy-money ratio
    - Emergy-money ratio (EMR) = Total emergy used in an economy / GDP
    - Amount of emergy that a dollar could buy in a specific year; buying power



Study Site

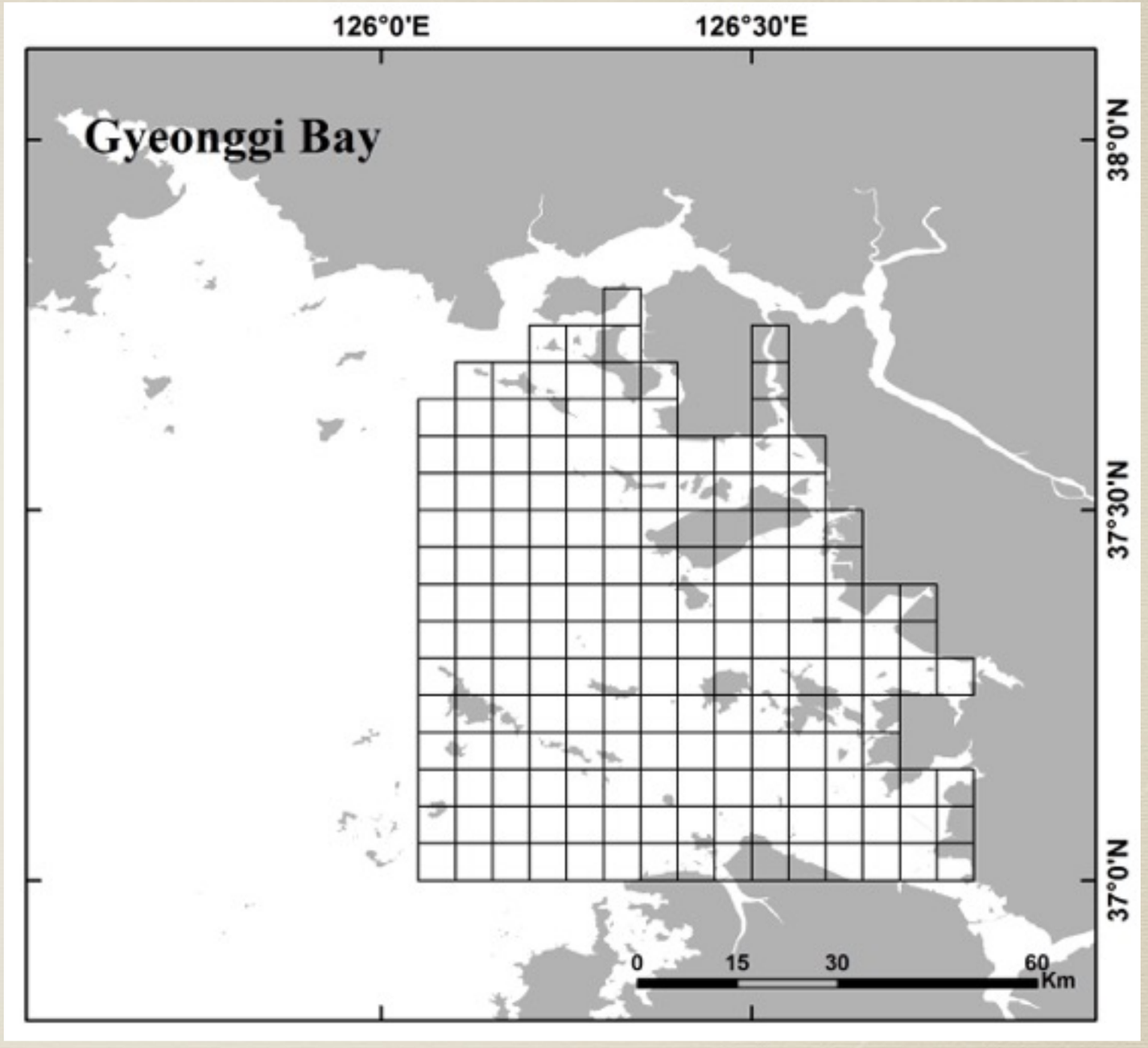
- Geonggi Bay, a demonstration site for spatial emergy evaluation
  - Multiple uses and conservation needs exist, but heavy development pressure and resultant marine ecosystem deterioration accumulating over the last decades



- Geographic features
  - Coastline length: 528 km
  - No. of islands: 130
  - Average depth: ca. 20 m
- Coastal population
  - 3.2 million
  - 956 people/km^2
- Fisheries production
  - 24,600 M/T
- Shipping & transport
  - 248,000 M/T
- Socio-economic activities
  - 18 national industrial complexes
  - 4 local industrial complexes

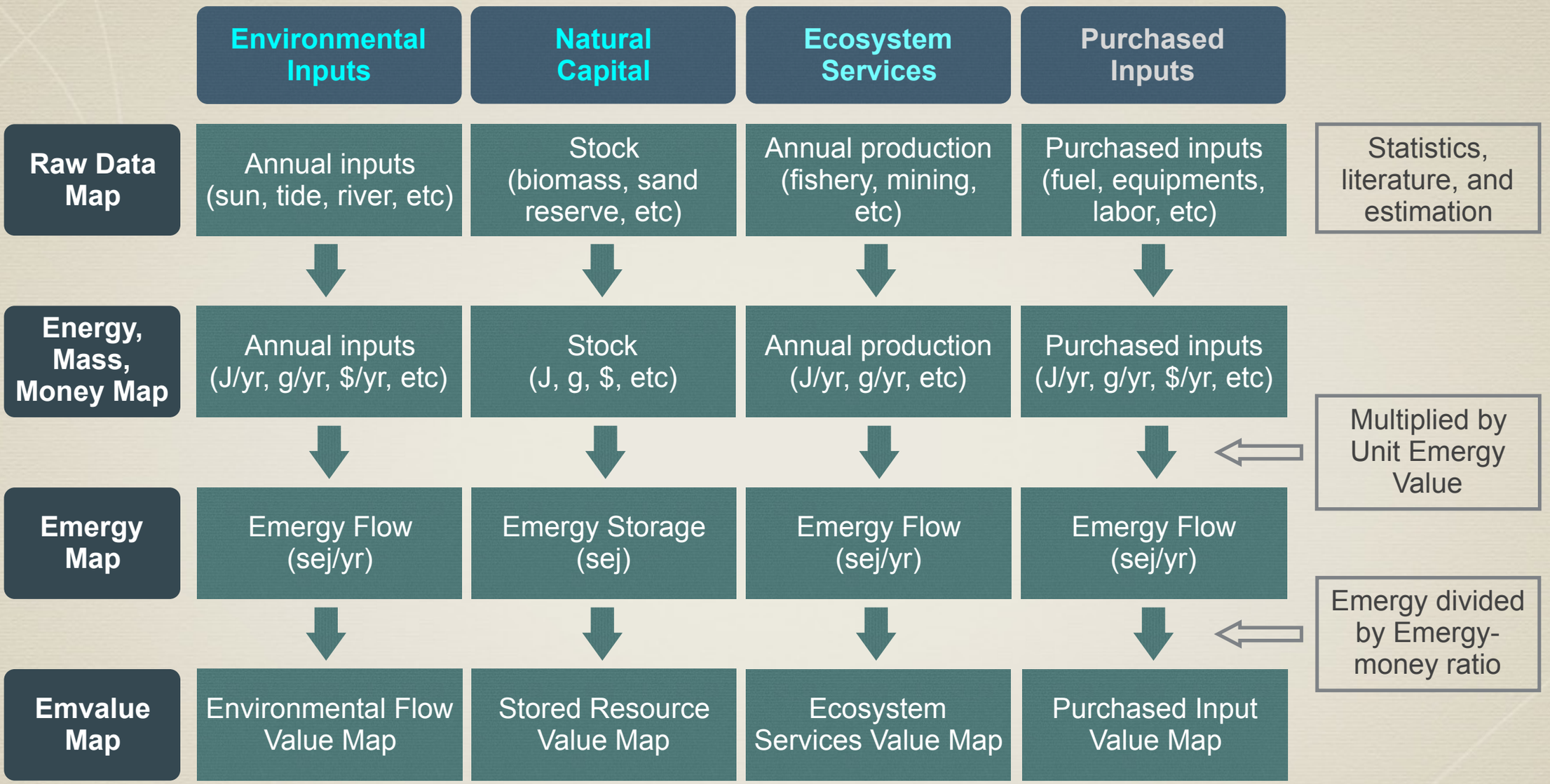
Spatial Emergy Valuation Procedure

- Raw Data Map
  - Program: ArcGIS
  - Spatial resolution: 1/20°
    (ca. 5 km, 24.5 km^2)



Spatial Emergy Valuation Procedure

- Spatial emergy mapping procedure for the Gyeonggi Bay



- Emergy (sej/yr) = Raw data × Unit emergy value (sej/J, sej/g, sej/$, etc)
- Emvalue (em$/yr) = Emergy (sej/yr) / Emergy-money ratio (sej/$)
  - Emergy-money ratio for Korea in 2011 = 5.36×10^{12} sej/$

- Raw Data Map
  - Raw data used in the case study (a partial list)

Category	Items	Unit	Reference
Environmental inputs	Sunlight	Insolation, J/m^2/yr	KMA
	Wind	Average wind speed, m/sec	KMA
	Rainfall	Annual rainfall, m/yr	KMA
	Wave	Wave energy density, kW/m Coastline, m	KIOST
	Tide	Average tidal range, m	KOHA
	River flow	River discharge, m^3/yr	MLTM
Storage	Benthos	Biomass, g/m^3	KOEM
Ecosystem services	Fishery production	Production, kg/yr	Yearbook
	Marine sand extraction	Extraction volume, m^3/yr	Yearbook

* KMA = Korea Meteorological Administration
* KIOST = Korea Institute of Ocean Science and Technology
* MLTM = Ministry of Land, Infrastructure and Transport
* KOEM = Korea Marine Environment management Corporation
* Yearbook = Statistical Yearbook of Korea and local governments

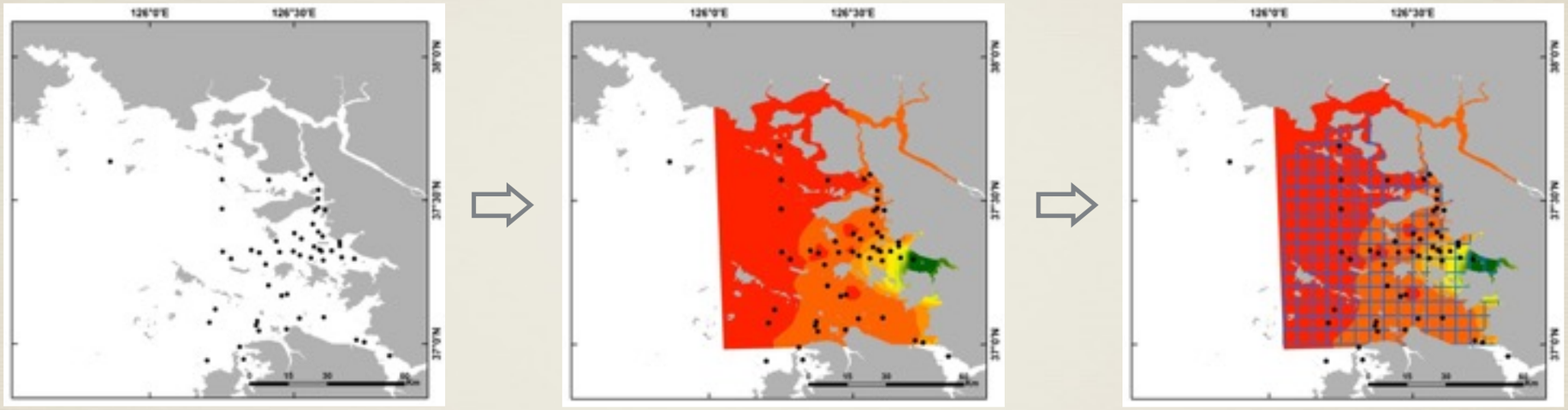
Spatial Emergy Valuation Procedure

- Raw Data Map
  - Transformation of point data into areal data
  - Estimation of unknown values

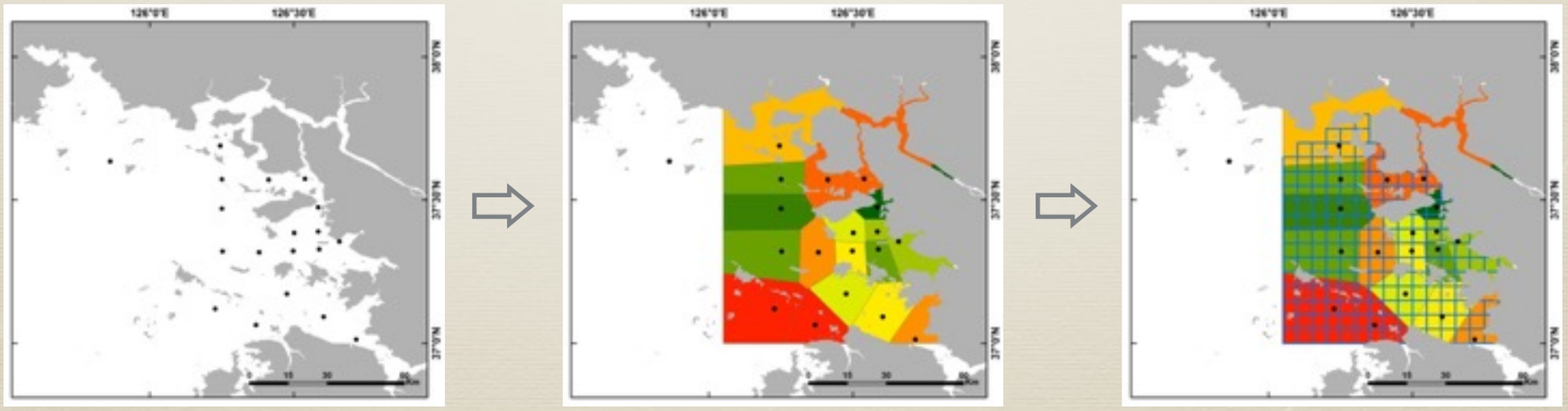
    A) IDW interpolation except benthos

    B) Thiessen polygon interpolation for benthos

A

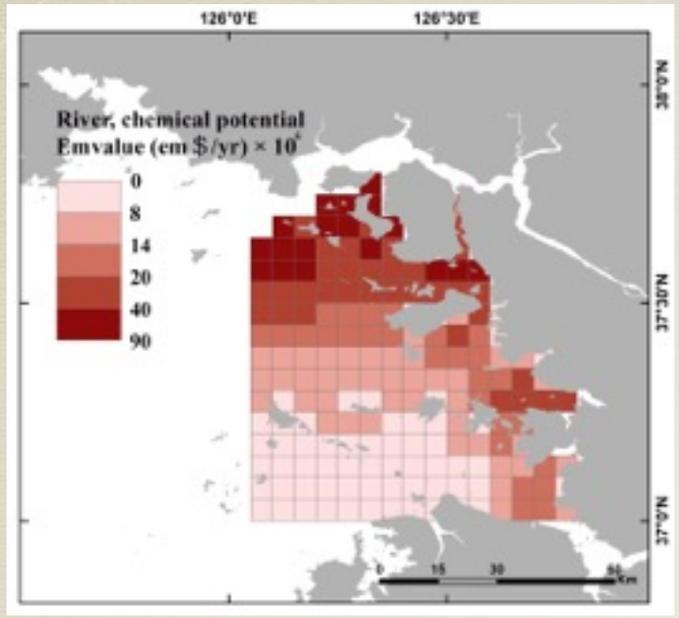


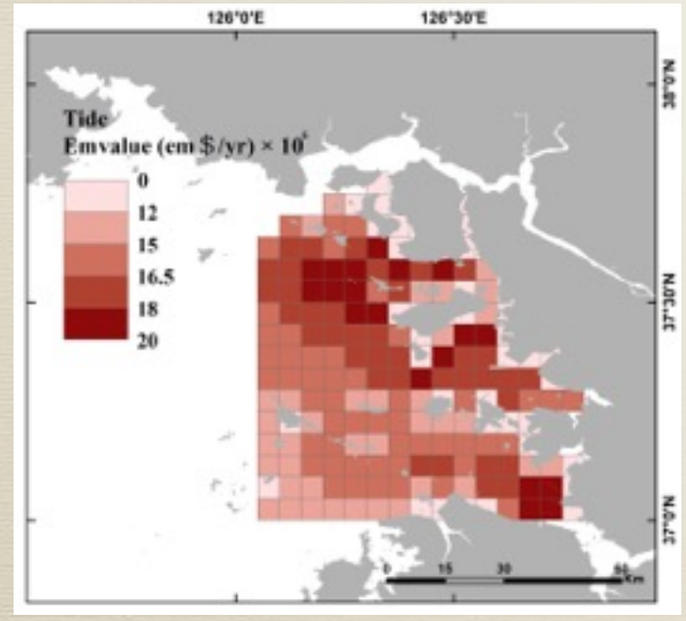
B

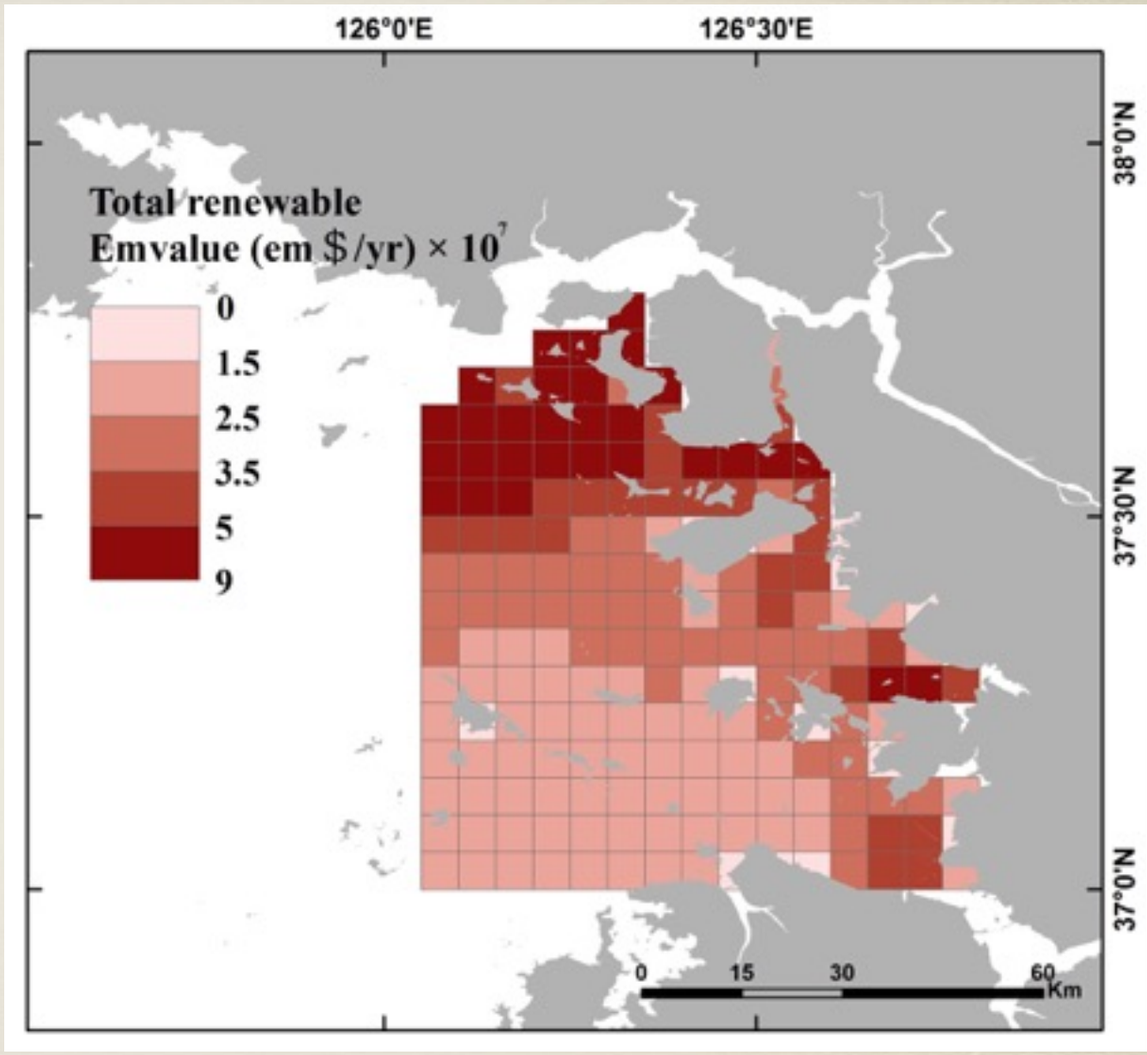


Emergy Value Maps

- Environmental inputs to the Gyeonggi Bay

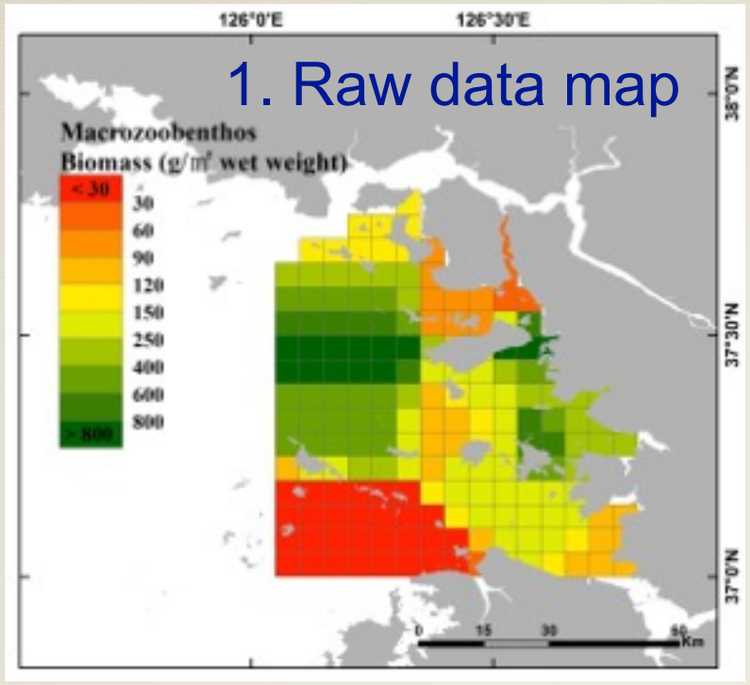


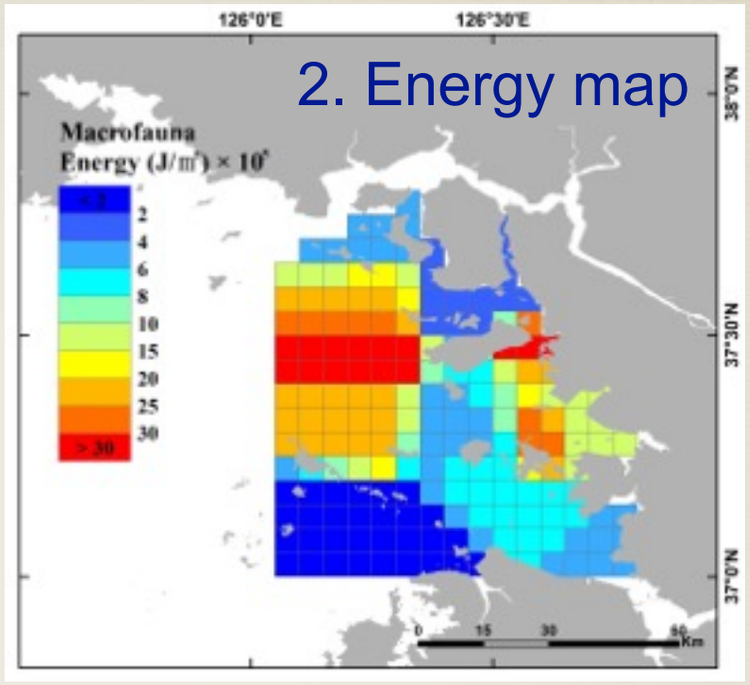


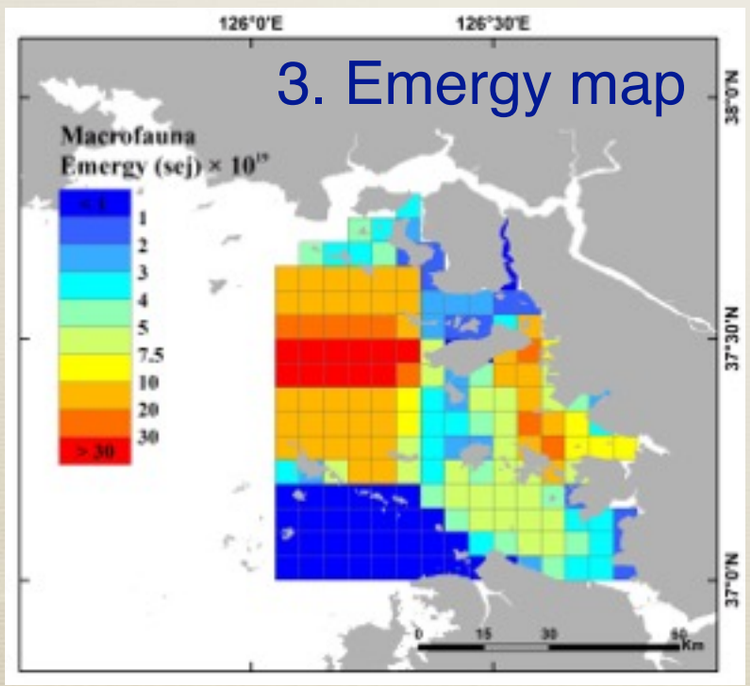


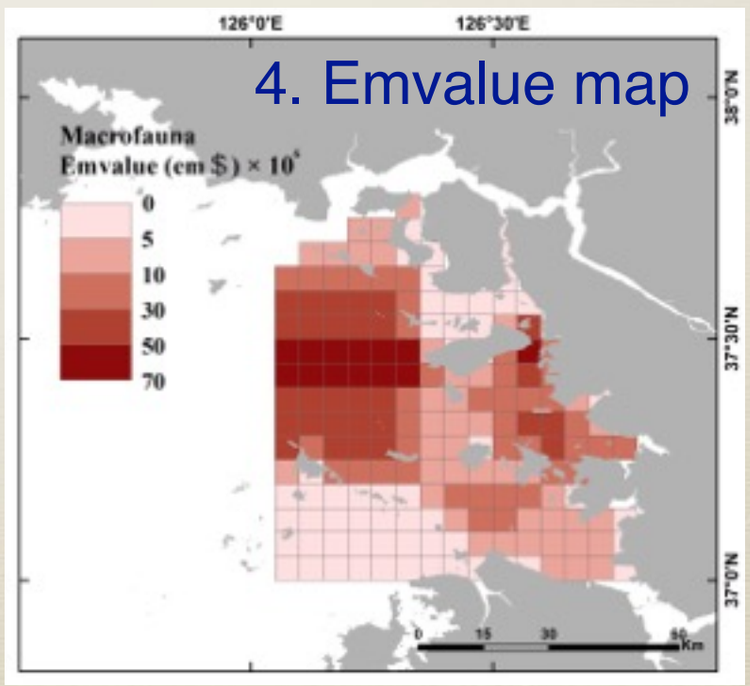
Emergy Value Maps

- Natural capital: Macrozoobenthos
  - Spatial distribution of benthic animals on a dry weight basis



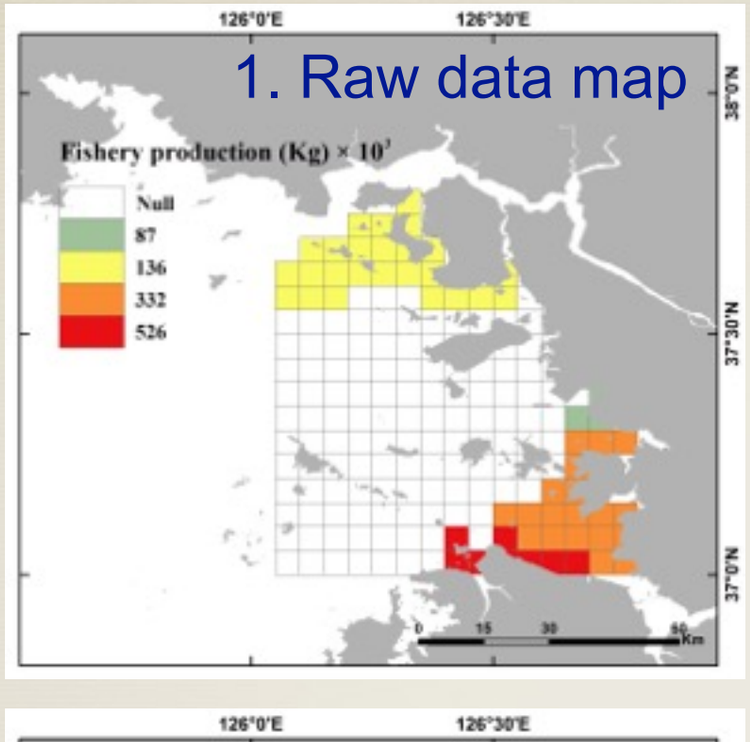


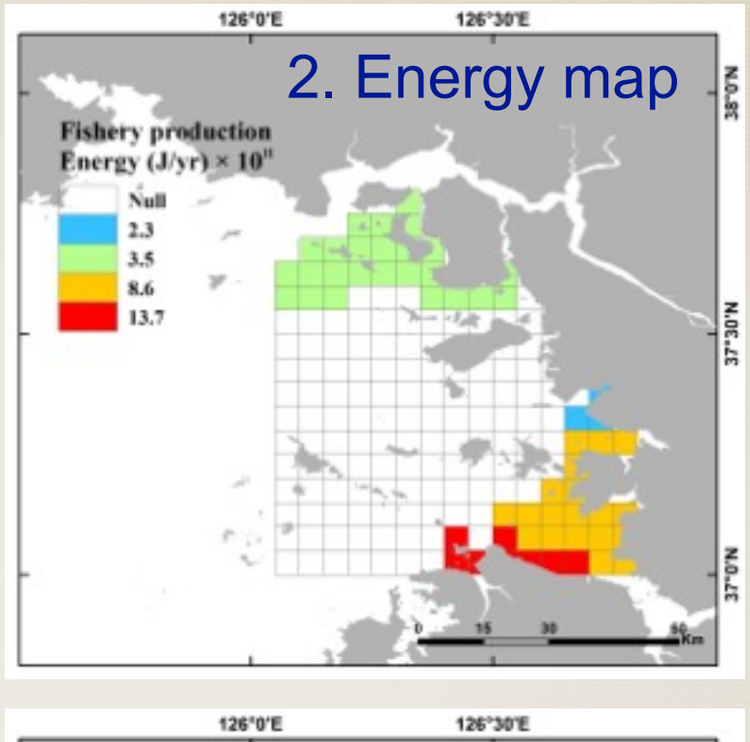


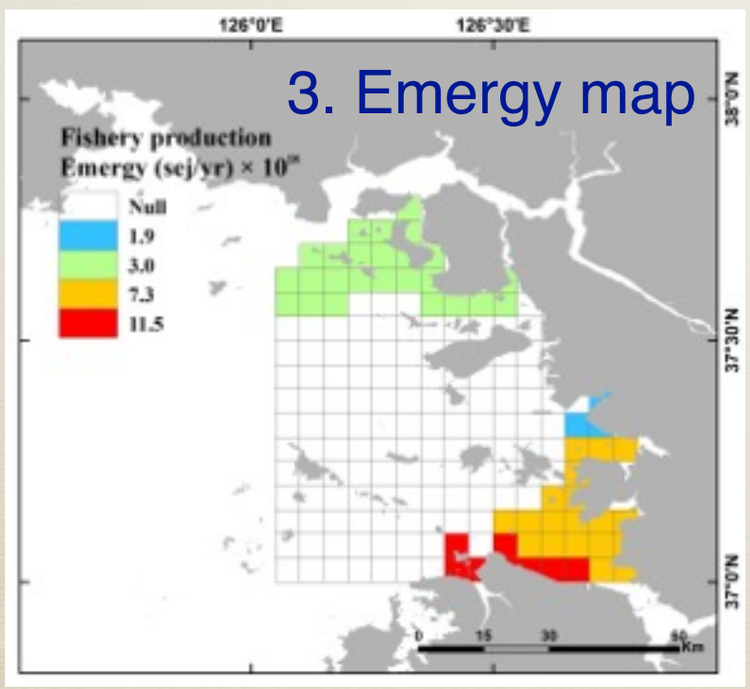


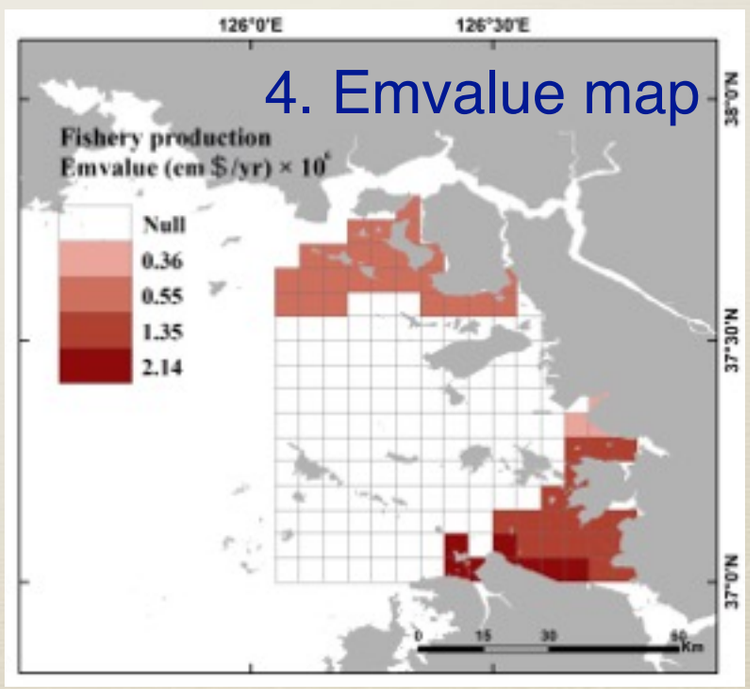
Emergy Value Maps

- Ecosystem services: Fishery production

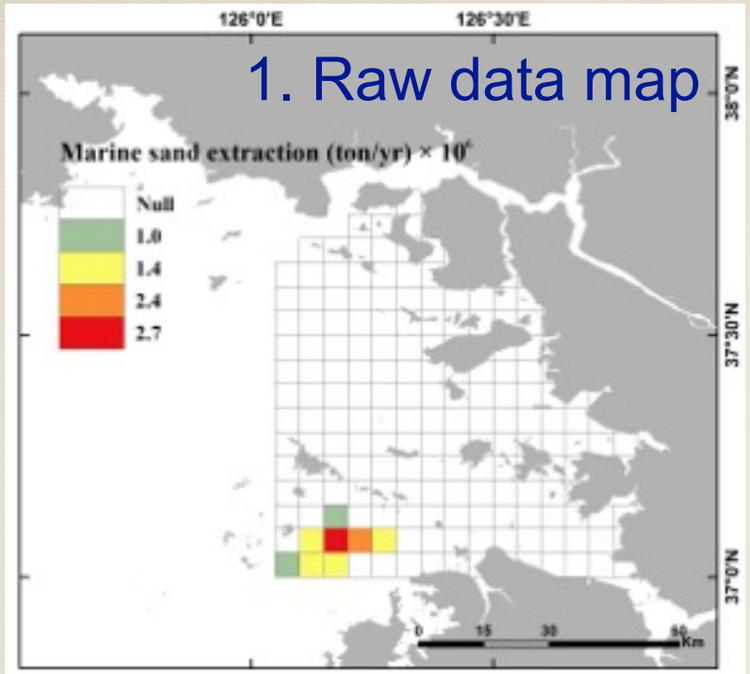


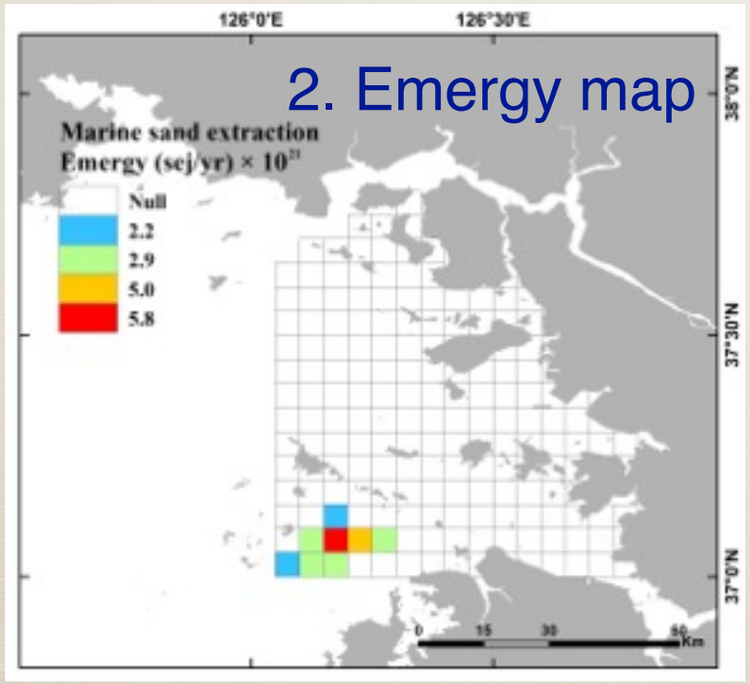


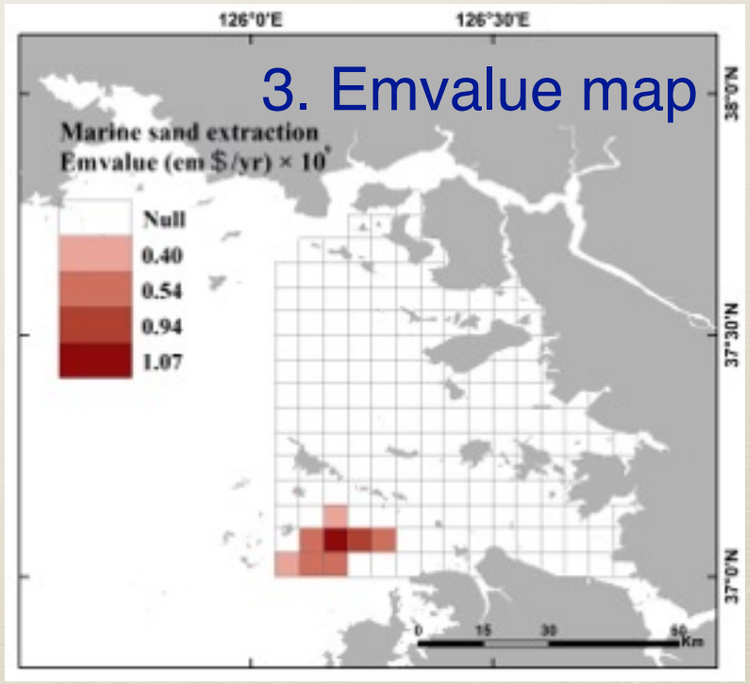




- Ecosystem services: Marine sand extraction





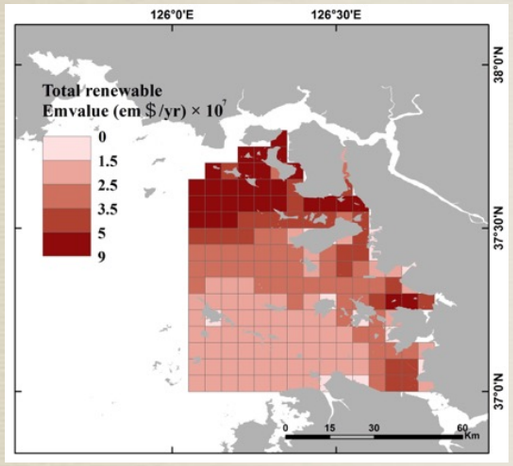


- Value maps of the Gyeonggi Bay ecosystem for conflict resolution and spatial decision making
  - Decision making on **priority areas for conservation** and management alternatives
  - **Trade-off analysis** among different uses of marine and coastal ecosystems
  - Integration of ecosystem services value into **environmental impact assessment**
  - **Cost-benefit analysis** of restoration projects and development proposals
  - Potential as **reference values** for future discussions on compensation and environmental taxes on marine and coastal activities in Korea
- **Awareness** raising and **education** on the importance of marine and coastal ecosystems

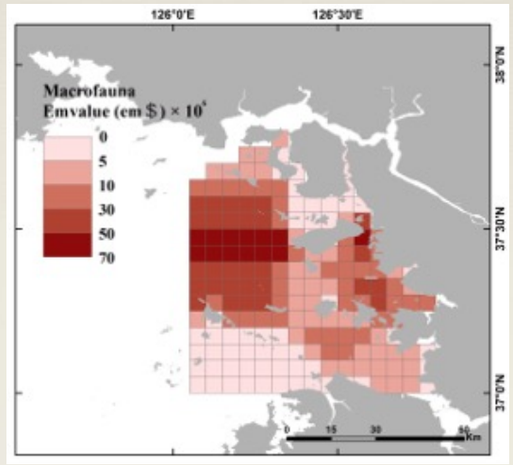
Emergy Value Maps

- Value maps of the Gyeonggi Bay ecosystem for conflict resolution and spatial decision making

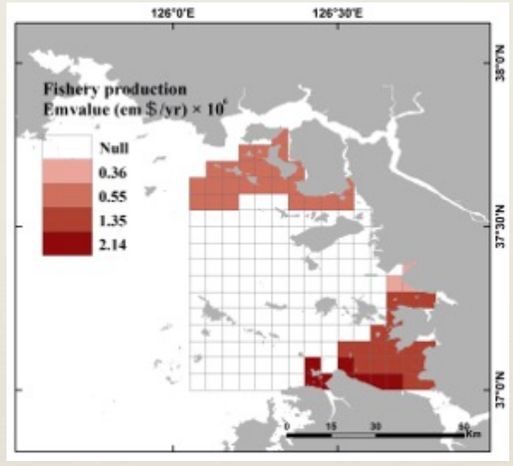
Environmental inputs



Natural Capital

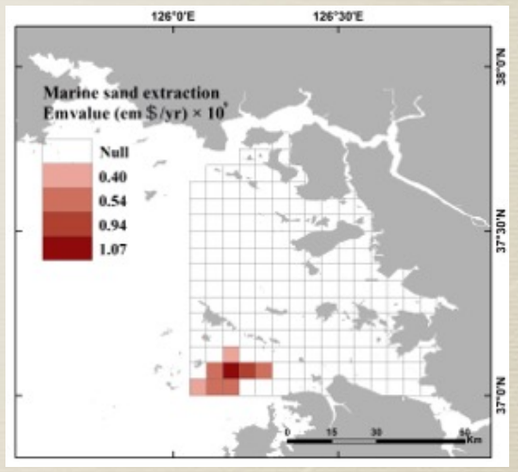


Ecosystem services



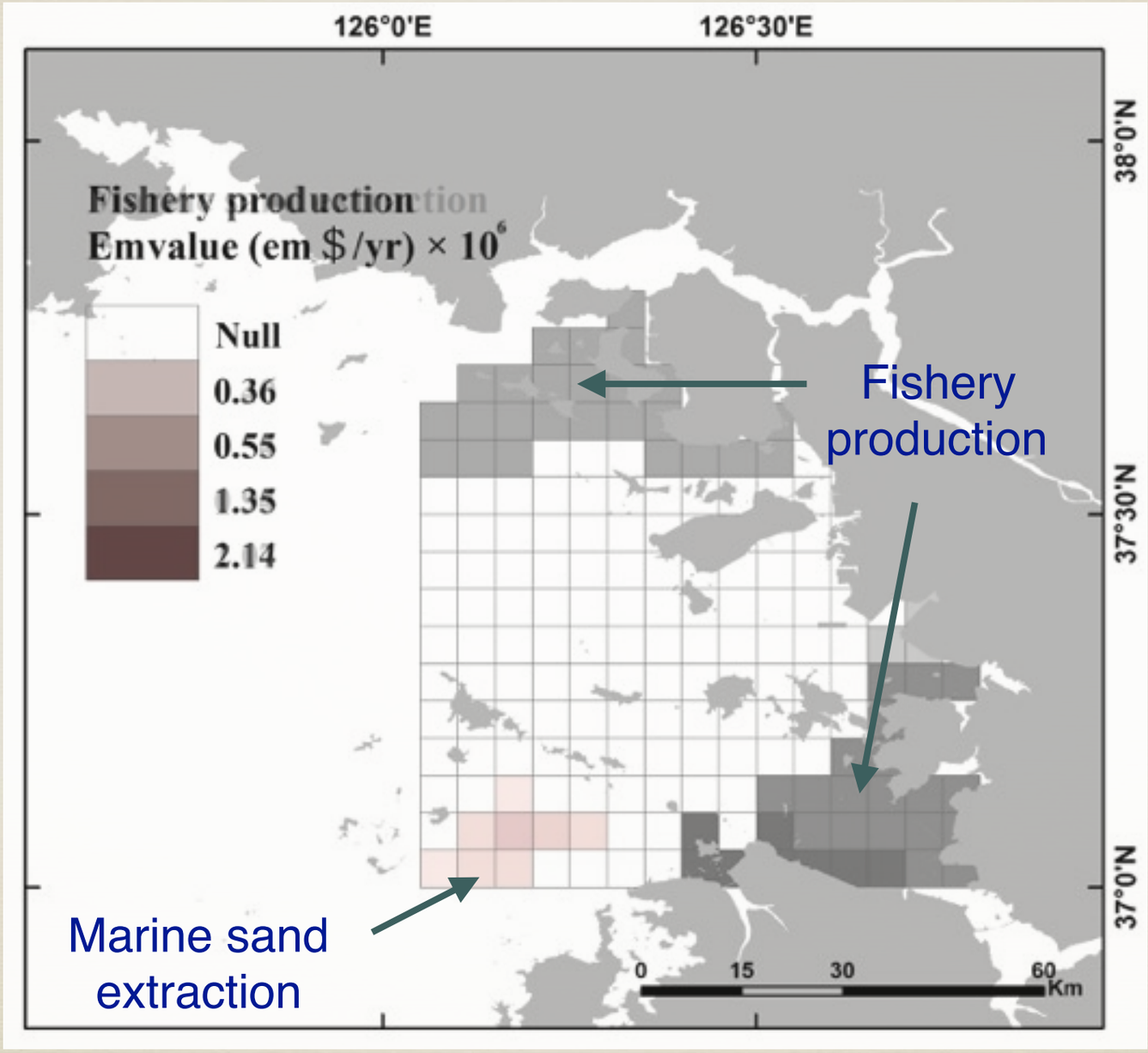
Conflicting uses

Marine Sand Reserve



Emergy Value Maps

- Value maps of the Gyeonggi Bay ecosystem for conflict resolution and spatial decision making



- Future works to be done
  - Missing components
    - Data collection for **more stored resources and ecosystem services**
    - **Human inputs** that are required to use ecosystem services of the bay
  - Emergy indices calculation
    - **Useful summary information** to understand the relationship between the Gyeonggi Bay ecosystem and socioeconomic demands
      - ex) Environmental loading ratio: the degree of environmental stress caused by socioeconomic activities; system level impact assessment
    - Need to **develop emergy indices** for more detailed impact assessment
  - How to apply this marine spatial planning framework to the **decision making** on marine and coastal issues in Korea?

Thank you for your attention!